

Office of the Chief Scientist for Human Factors

Human Factors Vertical Flight

Program Review
FY02



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The Federal Aviation Administration Office of the Chief Scientific and Technical Advisor for Human Factors (AAR-100) vertical flight human factors program is a relative new research domain. Research in this area is meant to identify specific human factors associated with helicopter flight regimes within the National Airspace System. Such issues include certification and regulation of civilian flights with night-vision-goggles devices, simultaneous non-interfering operations, and implications of tilt-rotor controls. Other current research requirements include head-up displays for general aviation rotorcraft, low speed helicopter/power lift displays, and vertical flight IFR approach lighting requirements.

The following report summarizes projects between October 1st, 2001 and December 31st, 2002. These projects attempt to address requirements identified by the Federal Aviation Administration Flight Standards and Certification offices. The intent of this report is to allow Federal Aviation Administration sponsors to determine whether their requirements have been satisfactorily addressed, allow investigators to receive feedback from Federal Aviation Administration sponsors and other interested parties, and to provide feedback to the AAR-100 vertical flight human factors program manager on the quality of the research program. Basically, this document is a means of holding each group (sponsor, investigator, AAR-100 program manager) accountable to ensure that the program is successful.

The vertical flight human factors program research has focused on two areas: night vision goggles and simultaneous non-interfering operations. The requirements that are mapped to these projects are located in Appendix II.

Appendix III lists the FY03 funded projects (\$118,000 contract dollars) and the proposed FY04 (estimated \$240,000 contract dollars) and FY05 projects.

To view project summaries, [pages 3-11](#). Please note, only one project summary available. Due to the late execution of the FY02 program, the other two projects did not collect any data or have enough information to write an annual summary.

To view requirements, [pages 12-25](#). Please note, the majority of these requirements are unfunded

Address questions or comments to:

William K. Krebs, Ph.D.

Appendix I

Human Factors Vertical Flight

FY02 Project Summaries

Due to the late execution of the FY02 program, the researchers did not collect enough data to warrant an annual report. Instead, Appendix I contains a brief description for one project. The other two FY02 projects “NVG resolution requirement” and “Simultaneous Non-interfering Operations - Quantify VFR Navigation Performance” will be summarized in the FY03 program review document.

<u>Project Title</u>	<u>Page #</u>
<i>NVG lighting requirement</i>	<u>4</u>

Project Title: *NVG lighting requirement*

Primary Investigator: Dr. Alan Pinkus, AFRL/HECV, Wright-Patterson AFB, OH
(e-mail alan.pinkus@wpafb.af.mil)

Co-Primary Investigator: Dr. Lee Task, (e-mail: task2@flash.net)

FAA Sponsor Organization ASW- (POC: Hooper Harris)

Sponsor's Requirement Statement: to validate and expand the draft AC material in Part 27 and Part 29 concerning NVG certification for rotorcraft civil operations. RTCA SC-196 Minimum Operational Performance Standards states a method of compliance for NVG lighting that is very similar to the method employed by the military. **Refer to page ## for a more detailed description.**

Research Project's Goal: This report is the second contractually required deliverable under the terms of the Interagency Agreement between the FAA and AFRL/HE. The purpose of this report is to describe and document possible alternative methods of assessing night vision imaging system (NVIS) lighting compatibility with night vision goggles (NVGs). Cockpit lighting can interfere with the proper operation of NVGs in several specific ways. In each interference mechanism the effect on the image seen through the NVGs is to reduce the light level or contrast of the useful image (the view outside the aircraft). This reduction in light level or contrast can be manifested as a reduction in visual acuity and/or as an observed loss of contrast or brightness. In order to better understand possible alternative methods of conducting NVIS lighting assessments, it is necessary to understand the currently accepted (baseline) method described in Mil Std 3009 (2001) and MIL-L-85762A, (1988). Since neither of these documents describes the currently used procedure in sufficient detail the technical report (Reising *et al.*, 1995) is relied on to provide a more complete description.

Technical Approach: The standard NVIS-compatible cockpit Lighting evaluation methods (AFRL/HEA NVG Training Research Team, Mesa AZ August 12, 2002) is a description of the baseline methodology used by AFRL/HEA to conduct NVIS lighting evaluations in the field. Since the joint FAA-AFRL research effort deals only with the evaluation of the lighting system with respect to interfering with the proper operation of the NVGs, only those sections of the AFRL/HEA procedures that deal with lighting interference are included. The other aspects of NVIS lighting evaluation, such as daylight readability and nighttime readability, are equally important in an overall NVIS evaluation but are not part of this research effort. Appendix B provides the NVIS evaluation procedures as described in Mil-Std-3009 and Appendix C provides excerpts from RTCA/DO-275 report

describing NVIS evaluation procedures. Although these 3 documents vary somewhat they are all essentially based on Mil-L-85762A. The following is a summary of the elements of the baseline assessment methodology.

Radiometric Measurement Equipment Baseline

Fundamental to the basic assessment of compatibility of NVIS lighting with night vision goggles is the concept that nothing in the cockpit should appear brighter (when viewing through the NVGs) than the external scene. For this baseline it was assumed that the external scene was illuminated/irradiated at a clear starlight level and was reflecting from material having the spectral reflectivity of tree bark. When this spectral distribution was weighted by the spectral sensitivity curve of the NVGs (so-called Class A NVG – see Mil-L-85762A for spectral sensitivity of both Class A and Class B NVGs) and integrated across all wavelengths, it provided a radiance of 1.7×10^{-10} watts/cm²-sr. Later, NVGs with a different objective lens coating were designed, designated Class B NVGs. Class B NVGs have a slightly different spectral sensitivity in the red region of the spectrum. When the tree bark/starlight spectrum is weighted by the Class B NVG spectrum and integrated one gets 1.6×10^{-10} watts/cm²-sr. ASC/ENFC 96-01 Rev 1 dated 22 March 1996 (section 4.6.2) and NADC-87060-20 dated 17 September 1987 (page 17) state NVIS radiance should be no more than 1.7×10^{-10} NR_A for Class A NVIS and 1.6×10^{-10} NR_B for Class B. However, the NADC document calls these values out when lighting equipment is illuminated to produce 0.1 ft-Lambert luminance and the ASC/ENFC document uses these values for the visual acuity assessment. Mil-L-85762A and ASC/ENFC 96-01 both provide tables, however, that call for a maximum radiance of 1.7×10^{-10} NR for either Class A or Class B NVG when the luminance is set to 0.1 ft-Lambert. The visual acuity evaluation procedures called out by AFRL/HEA (Appendix A) also uses 1.7×10^{-10} NR for either Class A or Class B NVG visual acuity assessment. Regardless of these minor differences, the concept is that no light in the cockpit, when set to its specified luminance, should exceed the specified NVIS radiance limit. This original concept (nothing in the cockpit should be brighter than the external scene under clear starlight) has been significantly modified as evidenced by the plethora of allowed NVIS radiance values for various cockpit light sources. Regardless of the rationale for these modifications, the NVIS lighting system was deemed to be compatible if all of the light sources in the cockpit, when set to their specified brightness (luminance) level, did not exceed the specified radiance (as weighted by the Class A or Class B NVG curve as appropriate).

In order to verify that the NVIS lighting was compatible according to the defined luminance/radiance values it is obviously necessary to have photometric and radiometric equipment capable of measuring the luminance and radiance values. Portable equipment of this nature is expensive, not easy to use in the field, and/or not very accurate. For purposes of this research effort there is no inexpensive, commercially available equipment suitable to making these kinds of

measurements in the field. The following is a sample list of devices that have been or could be used and the associated capability and cost.

- NVG 103 - Hoffman Engineering, measures NVIS radiance, \$20,000
- PR 1530 AR - Photo Research, measures NVIS radiance, \$28,000+
- Minolta LS-100 Photometer - Minolta, measures luminance, \$3,145

Visual Acuity Assessment Baseline

An alternative or additional method of assessing NVIS lighting compatibility is to conduct a visual acuity degradation inspection. This methodology is described in various references (Mil-L-87762A, Mil-Std-3009, ASC/ENFC 96-01, RTCA/DO-275). Appendix A contains the current NVIS lighting evaluation methodology description as practiced by AFRL/HEA (night vision training research team, Mesa, AZ). The following elements are required to conduct this baseline visual acuity assessment as described in Appendix A and/or the other listed references.

- Visual Acuity (VA) Chart – Visual acuity is assessed using 1951 USAF Tri-Bar Chart with a photopic modulation (Michelson) contrast of 70%. This chart was acquired from Rochester Institute of Technology and is no longer available. However, 1951 USAF Tri-Bar Charts are available from Hoffman Engineering, (high, medium, low contrast) for \$575 each.
- VA Chart Irradiance Source – The USAF Tri-Bar chart is illuminated to a level of 1.7×10^{-10} NR_B on the white parts of the chart. A Hoffman Engineering LM-33-80A (available from Hoffman Engineering, \$5,000) is used to illuminate (irradiate) the chart.
- VA Chart Irradiance Verification Equipment – A Pritchard PR 1530-AR spot radiometer with a Class B filter is used to set the above noted radiance on the white part of the VA chart. This spot radiometer is available from Photo-Research for about \$28,000 plus, depending on options. The radiance of the chart is then monitored using an NVG 103 inspection scope (available from Hoffman Engineering for \$20,000).
- Evaluation Facility “Darkness” Verification – The referenced documents state that the evaluation is “conducted in a darkened hangar, which is sufficiently light-tight to prevent undesired or outside light sources from interfering with any of the measurements.” There are no quantitative means listed for verifying the test facility is sufficiently dark. However, if one cannot get the chart radiance low enough (1.7×10^{-10} NR_B) then it can be assumed the facility is not dark enough.

Evaluator Characteristics – Baseline methodology requires the evaluator be “trained” but there is no published documentation that defines the attributes or skills that one needs to have to be an evaluator. No certification system exists.

ALTERNATIVE VISUAL ACUITY ASSESSMENT METHODOLOGY

This section explores alternative equipment/methodology to conduct an NVIS lighting assessment using the visual acuity approach. The objective is to produce the same level of results (acceptance/rejection probability) as the baseline visual acuity described earlier but use much less expensive equipment. The following sections parallel the baseline section headings but describe possible alternative equipment/procedures to theoretically achieve the same results.

Alternative Visual Acuity Chart – The USAF 1951 Tri-Bar chart is currently available (for free) on the WEB in a PDF file format. This version of the chart, when viewed from a distance of 20 feet, provides visual acuity patterns (tri-bars) for Snellen acuities of about 20/90 and better. Since currently available NVGs are capable of about 20/50 Snellen acuity for the radiance levels noted above this chart should be able to serve as a suitable visual acuity chart. However, it should be printed on white bond paper using a laser printer to insure chart image quality. In addition, this chart prints out in high contrast (greater than 90%) unlike the 70% listed for the baseline chart. It may be possible to make this PDF file print out at lower contrasts or it may be that the difference in contrast levels will not significantly affect evaluation results.

Another alternative to the USAF Tri-Bar Chart PDF file is to use publicly available software (already supplied to the FAA) that was developed at AFRL/HECV that prints out square-wave grating patches for a wide range of Snellen acuities (selectable) and viewing distances (also, selectable). This grating chart maker (GCM) software could be used to produce a few well-chosen gratings that could serve as an appropriate visual acuity assessment chart. Again, the software currently prints these grating patches as high contrast (greater than 90%).

Alternative Chart Irradiance Source – The spectral distribution of the light source used to illuminate (irradiate) the visual acuity chart is not critical but there does need to be a way to verify that the VA chart is illuminated (irradiated) to the correct level (within reasonable accuracy). It has been determined that a 7 1/2 watt bulb in a bell shaped housing (an inexpensive, commercially available lamp), operating at 110 volts, with a 1/8 inch aperture in a thin, opaque baffle covering the bell housing, will provide the appropriate level of NVIS radiance at a distance of approximately 21 1/2 feet. However, if the evaluation facility has significant light leaks that provide some level of ambient illumination/irradiance on the VA chart, then a means must be provided to reduce the radiance level in a controlled fashion or the facility may need to be declared unsuitable for testing.

Alternative Chart Irradiance Verification Equipment/Means – If the facility proves to be dark enough (see section below) then there may not need to be any means to verify chart radiance directly. It may only be necessary to insure the 7 1/2 watt bulb is operated at 110 VAC using a volt-meter. Alternatively, it may be possible to use a volt-meter to determine the local line voltage and adjust the distance from the bulb to the chart using a pre-calculated conversion chart. Another alternative is to acquire an inexpensive light (illuminance) meter (about \$120) and attach it to the eyepiece of the night vision goggle (NVG) that is to be used. It may then be possible to calibrate the combination of the NVG and the light meter using the 7 1/2 watt bulb illuminator at a specified distance in a completely dark (smaller) room. The NVG/light meter combination could then be used to verify the radiance level of the chart. Although this methodology is somewhat complex, it is theoretically doable.

Means of Verifying Darkness Level of Evaluation Facility – If the NVG/light meter procedure described above is fully successful then the NVG/light meter combination could be used directly to verify that the test facility is dark enough to conduct a valid evaluation. Alternatively, it is possible that a very low resolution visual acuity (such as 20/200) grating patch could be used. If this very low resolution patch is not resolvable through the NVGs with only ambient (facility light leaks) irradiation available, then the facility should be dark enough. It will be necessary to conduct a small amount of research to determine what the Snellen acuity should be for the grating patch, if this approach is used.

Alternative Evaluator Characteristics – The baseline assessment procedure states that the evaluator should be trained, but does not go in to any further detail. At a minimum, the evaluator should have a sound understanding of the basic operation and adjustments of the NVGs to be used and be familiar with possible lighting interference mechanisms. In addition, the evaluator should have sufficient knowledge of the specific evaluation methodology to be able to judge the validity of the equipment and procedures used in the evaluation. The visual acuity of the evaluator, when viewing through NVGs, should be capable of some minimum acceptable level. Selection and training criteria for an NVIS lighting assessment evaluator is not part of this research effort, but the above criteria/characteristics should be considered in selecting/qualifying an individual to be an evaluator.

OBJECTIVE NVIS ASSESSMENT METHODOLOGY

The baseline NVIS lighting assessment methodology very clearly establishes an objective means to verify NVIS lighting acceptability. This includes previously described radiometric measurement equipment to measure the NVIS A or NVIS B radiance and photometric equipment to measure the luminance of the light source. The light source or display is deemed to be NVG compatible (acceptable) if the measured (or calculated) radiance is within permitted levels when the measured (or calculated) luminance is at the specified level. The problems with the baseline methodology are the high cost of the measurement

equipment and the difficulty of using this expensive equipment for a field evaluation. In addition, the NVG 103 inspection scope designed for use in field evaluations is relatively inaccurate (on the order of +/- 30%).

Given the difficulty of using this expensive equipment to conduct field evaluations, it is unlikely that one can achieve comparable results with an inexpensive device. Ideally, one would like to have a very clear procedure and a device that would provide a very clear reading that could be translated to an unambiguous accept or reject decision. The following devices/procedures are possible approaches along the pathway to this non-existent ideal device.

NVG light output assessment method

A relatively inexpensive illuminance meter (\$120) has been identified that, when slightly modified, can be attached to the eyepiece of an NVG to provide a reading proportional to the light output of the NVGs. There are two possible approaches to using this device as an NVIS compatibility meter, which are described below:

Absolute light level criteria – For this approach the combination NVG and light meter must be calibrated so that output luminance values can be related to NVIS radiance values. The light meter is first modified by removing the cosine plate (diffuser plate) that covers the detector. This increases the sensitivity of the device so that it can be used to assess the light output of the NVG. The NVG/light meter combination is calibrated by pointing the NVG at a white, diffusely reflectively surface (TBD – perhaps a white bedsheets) that is illuminated by the previously described 7 1/2 watt lamp with 1/8 inch hole. The distance from the illuminator to the white reflective surface and the distance from the NVG/light meter to the white surface need to be appropriately specified distances (TBD during research). The reading obtained from the light meter during this procedure will be used to calculate a conversion factor that will allow one to convert the light meter reading to NVIS radiance.

The second step in this procedure is to position the calibrated NVG/light meter in the appropriate location in the cockpit pointed toward the outside. With the cockpit lights off, a reading is taken from the NVG/light meter – this is the baseline reading (a measure of the ambient lighting in the “dark” facility). Without moving the position of the NVG/light meter the cockpit lighting is turned on (it should have already been adjusted to an “operationally relevant” level). This provides a second reading from the NVG/light-meter. The first reading is subtracted from the second reading to provide an NVIS radiance value that is due to incompatible light in the cockpit. If this value does not exceed a (TBD) certain criteria value, then the light system is considered to be compatible. This same procedure is then repeated for other view directions out of the cockpit to verify there is no problem in viewing out of the aircraft in any relevant direction. Note that this procedure does not require an absolutely dark test facility since the baseline ambient level is subtracted from the cockpit lighting reading.

One caution when using this approach: a visual inspection using the NVG should be performed first to insure there are no objectionable direct reflections in the windscreen or canopy. Since the light reading is an average across the field of view of the NVGs, it cannot differentiate between a single, bright point source reflection (which might be visibly objectionable) and a large area dim reflection (which might be perfectly acceptable). It is apparent that there is still an element of subjective assessment using this device, even if it is considered fully successful.

Relative light level criteria – For this method it is not necessary to calibrate the NVG/light meter combination. A large reflective surface (e.g. white bedsheet) is positioned a specified (TBD) distance from the cockpit and illuminated with the 7 1/2 watt bulb illuminator (previously described) from a specified (TBD) distance. The NVG/light meter is then positioned in its operational location in the cockpit and pointed toward the reflective surface. A baseline reading is taken with all the cockpit lights off. Then the cockpit lights are turned on and a second reading is taken. The cockpit lighting is considered acceptable if the second reading is no more than (TBD) percent higher than the first reading. This indicates the incompatible lighting in the cockpit is providing only a small (TBD percent) amount of interfering light compared to the light from the external scene. The implication is the interfering light is negligible compared to the external scene light level (which will be in the vicinity of the clear starlight levels used for present visual acuity assessments of NVIS lighting). The same “bright source reflection caution” noted above also applies here.

NVG objective lens irradiance method

This approach uses the same light meter/NVG combination noted above. However, in this approach the objective lens of the NVG is capped with a diffusing plastic material, which acts like a cosine plate used for illuminance meters. The objective lens is adjusted for closest focus so that if there is any minor amount of light getting through the diffuser undiffused it will be defocused by the objective lens. The test is then conducted in a dark facility (level of darkness may be determined by the Snellen acuity chart method described previously). The NVG/light meter (with a diffuser over the objective lens) is positioned appropriately in the cockpit. A baseline reading is taken with all cockpit lighting off. Then all the cockpit lighting is turned on and a second reading is taken. The baseline reading is subtracted from the second reading. If this value is equal to or less than the specified value, then the cockpit lighting is considered to be compatible.

Note that this measurement combination also needs to be calibrated using a procedure similar to the one described previously, except that there is a diffuser over the objective lens in this approach. This approach provides a measure of the NVIS Irradiance at the surface of the objective lens of the NVG. This approach is less sensitive to reflections in the windscreen/canopy, but should be

more sensitive to general light pollution in the cockpit. It is highly probable that the number readings obtained with this method will be more sensitive to positioning of the NVG/light meter combination.

DISCUSSION

It is highly likely that the alternatives under consideration for providing the main elements needed to conduct visual acuity assessment will be successful resulting in much less expensive testing. However, the selection and training of the evaluators will still need to be addressed. The two objective assessment methods will probably be partially successful, but most likely neither one of them could be considered a complete, stand alone device for determining acceptance/rejection of the lighting system under test. No other alternatives have been submitted by any of the associated organizations. The other alternatives previously presented at the June 18, 2002 meeting in Washington DC are less likely to succeed than the ones presented here. Therefore, with the limited time and funding available, we plan on tackling the alternatives described herein as the ones that have the best chance for success.

REFERENCES:

ASC/ENFC 96-01 REV 1, (1996), Interface Document, Lighting, Aircraft, Interior, Night Vision Imaging System (NVIS) Compatible, 22 March 1996, ASC/ENFC, Wright-Patterson AFB, OH.

Inter-Agency Agreement DTFA01-02-X-02017 (February 2002) Between the Federal Aviation Administration (FAA) and the Department of Defense Air Force Research Laboratory (AFRL/HEC, Wright-Patterson AFB.

MIL-STD-3009, 2 February 2001, *Department of Defense Interface Standard for Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible.*

MIL-L-85762A, 26 August 1988, *Military Specification, Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible.*

Reising, J.D., Antonio, J.C., and Fields, B, (1995), *Procedures For Conducting A Field Evaluation Of Night Vision Goggle-Compatible Cockpit Lighting*, AL/HR-TR-1995-0167

Reetz III, Ferdinand (1987), *Rationale behind the requirements contained in military specifications MIL-L-85762 and MIL-L-85762A*, Technical Report NADC-87060-20, 17 September 1987, Naval Air Development Center, Warminster, PA.

RTCA/DO-275, October 12, 2001, *Minimum Operational Performance Standards for Integrated Night Vision Imaging System Equipment*, prepared by SC-196, Washington, DC.

Appendix II

Human Factors Vertical Flight Research Requirements

Research requirements exist in the AAR-100 interactive management database that allows program managers to track research requirements for each Federal Aviation Administration sponsor.

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Requirement ID: 617Sponsor Organization: ASWPOC: Lorry FaberRequirement Title: Head-up display for GA and rotorcraftFunded Requirement:

- FY02: No
- FY03: No
- FY04:
- FY05:

Requirement Statement: This research should provide guidance on best practices for Avionics manufacturers to design HUDs for civil aircraft and evaluation criteria for certification personnel. This is a critical project since there is very little regulatory guidance. Currently, some advisory material is attempting to be developed in the Transport Directorate, but very little consideration is being taken for small airplanes and rotorcraft. There are supplemental type certificates for implementation for HUDs in these aircraft and guidance would be helpful. 543

Background: Project Entails: Head-up Display (HUD), GA and rotorcraft: Literature review. Problems associated with civil and military GA rotorcraft HUD applications regarding conformal versus compressed formats offered by present manufacturers as well as issues of formatting and clutter, along with the use of highway-in-the-sky depictions on the HUD. Includes transition and training issues. This research should provide guidance on best practices for Avionics manufacturers to design HUDs for civil aircraft and evaluation criteria for certification personnel. This is a critical project since there is very little regulatory guidance. Currently, some advisory material is attempting to be developed in the Transport Directorate, but very little consideration is being taken for small airplanes and rotorcraft. There are supplemental type certificates for implementation for HUDs in these aircraft and guidance would be helpful. „h CAN BE COMBINED WITH RESEARCH REQUEST AIR 21 HEADS-UP DISPLAY CERTIFICATION CRITERIA:HOWEVER, ROTORCRAFT NEEDS TO BE A SEPARATE PLATFORM FOR THE RESEARCH!

Output:Regulatory Link:

Requirement ID: 645

Sponsor Organization: AFS

POC: Hooper Harris

Requirement Title: Low Speed helicopter/powered lift displays

Funded Requirement:

- FY02: No
- FY03: No
- FY04:
- FY05:

Requirement Statement:

Background: Helicopter/powered lift operations at low speed requires instrumentation which display information not normally found on conventional airplane instruments. One Avionics System is attempting certification of a system that indicates accuracy below 50 knots. Additional human factors research needs to be conducted to develop certification standards (pilot and aircraft) for these future avionics systems. These displays are integral to approvals for helicopters and tiltrotors to conduct steep angle, decelerative GPS approaches to heli/vertiports, thereby exploiting the capabilities of GPS and DGPS for vertical flight. This research is critical to the implementation of the infrastructure for helos and tiltrotos per HR-1000, section 103 of the agency's performance plan

Output:

Regulatory Link:

Requirement ID: 618Sponsor Organization: ASWPOC: Lorry FaberRequirement Title: Night vision goggle Certification IssuesFunded Requirement:

- FY02: Yes
- FY03: No
- FY04:
- FY05:

Requirement Statement: This research will contribute to formulating an AC and Noticed for Proposed Rulemaking (NPRM) for civil operations for general aviation and rotorcraft for NVG certification and operations. Also, a Technical Standard Order is needed for the Night Vision Goggle equipment. There is currently no guidance for NVG's except for military specifications and regulations which may not be adequate for civil use. Two NVG civil certifications already exist for a FAR Part 27/29 rotorcraft flying under FAR Part 135 operations. There are other supplemental type certificate applications concerning NVG usage as well as waivers to the operating rules. Research and potentially flight testing is required immediately so the appropriate regulatory statements are written and adopted.774

Background: Project Entails: Night vision goggle operational problems: Literature review and survey of existing issues. This need stems from recent approval for specific civilian use of NVG and the requirement to complete the RTCA SC-196 Minimum Operational Performance Standards. Examination of use in expected civilian operations as compared with military operational data to determine specific problems that may be associated with device use (CAMI proposed this examination originally in 1995). Also, determine minimum operational criteria for types of NVGs & NVG compatible aircraft lighting to be used, as well as training guidance for this equipment for civilian use. This research will contribute to formulating an AC and Noticed for Proposed Rulemaking (NPRM) for civil operations for general aviation and rotorcraft for NVG certification and operations. Also, a Technical Standard Order is needed for the Night Vision Goggle equipment. There is currently no guidance for NVG's except for military specifications and regulations which may not be adequate for civil use. Two NVG civil certifications already exist for a FAR Part 27/29 rotorcraft flying under FAR Part 135 operations. There are other supplemental type certificate applications concerning NVG usage as well as waivers to the operating rules. Research and potentially flight testing is required immediately so the appropriate regulatory statements are written and adopted.

Output:

Regulatory Link:

Requirement ID: 799Sponsor Organization: ASWPOC: Lorry FaberRequirement Title: NVG lighting requirementFunded Requirement:

- FY02: Yes
- FY03: No
- FY04:
- FY05:

Requirement Statement: This research will validate and expand the draft AC material in Part 27 and Part 29 concerning NVG certification for rotorcraft civil operations. This material only suggests one means of compliance which many operators have complained is not cost effective and not the sole means. However, without this research there is uncertainty if another means may be safe to an overall NVG operation. This research is using the aid of the US military since they too have agreed that alternate methods needs to be explored for cost and immediate implementation. Three NVG civil certifications already exist for a FAR Part 27/29 rotorcraft flying under FAR Part 135 operations, with more to follow. The last certification effort had requested an unknown method to both the FAA and DoD. Research and potentially flight testing is required immediately so the appropriate alternate methods can be justified when requested.910

Background: RTCA SC-196 Minimum Operational Performance Standards states a method of compliance for NVG lighting that is very similar to the method employed by the military. Many civilian operators, FAA test pilots and small manufacturers are concerned that this method is expensive and not necessarily the only method out there. However, due to lack of data, the current method is the only one proven to be safely employed as an effective evaluation process. The Committee agreed that this method will be cited in the document with a caveat that this is a recommendation only and that applicants applying for NVG certification has the right to not use this method if another method is appropriately documented and justified. As a result, many FAA and DoD are concerned that the alternate means of compliance that are suggested from applicants may not be totally proven to be safe. Most applicants (or small manufacturers) have limited budgets and therefore do not commit testing funds to R&D as other agencies might do. It is very difficult for the FAA to refute the data if the data is well justified for the small operation. Thus, the impetus for the need for this research.

Output: Final report detailing results of repeatability testing for military accepted methodology and describing the alternative, inexpensive methodologies that provide the same results

Regulatory Link: RTCA-196

Requirement ID: 798Sponsor Organization: ASWPOC: Lorry FaberRequirement Title: NVG resolution requirementFunded Requirement:

- FY02: Yes
- FY03: No
- FY04:
- FY05:

Requirement Statement: This research will validate and expand the draft AC material in Part 27 and Part 29 concerning NVG certification for rotorcraft civil operations as well as the draft TSO concerning Night Vision Goggles. This material only suggests a minimum NVG resolution requirement that many European manufacturers and US civil operators are too stringent. The requirement was written because no data exists as to the existing acceptable resolution for human being for safe NVG flight. The requirement was a consensus decision based on NVG manufacturer statistics of current product use which did not include a wide variety of resolution levels. However, without this research there is uncertainty if another means may be safe to an overall NVG operation. This research is using the aid of the US military since they too have agreed that alternate methods needs to be explored for cost and immediate implementation. Three NVG civil certifications already exist for a FAR Part 27/29 rotorcraft flying under FAR Part 135 operations, with more to follow. Research and potentially flight testing is required immediately so the appropriate alternate resolutions for NVGs can be justified when requested. This need stems from recent approval for specific civilian use of NVG and the recent completion of the RTCA SC-196 Minimum Operational Performance Standards. Examination of use in expected civilian operations as compared with military operational data to determine specific problems that may be associated with device use (CAMI proposed this examination originally in 1995). This research will contribute to formulating an AC and Noticed for Proposed Rulemaking (NPRM) for civil operations for general aviation and rotorcraft for NVG certification and operations. Also, a Technical Standard Order is needed for the Night Vision Goggle equipment. There is currently no guidance for NVG's except for military specifications and regulations which may not be adequate for civil use. Three NVG civil certifications already exist for a FAR Part 27/29 rotorcraft flying under FAR Part 135 operations. There are other supplemental type certificate applications concerning NVG usage as well as waivers to the operating rules. Research and potentially flight testing is required immediately so the appropriate regulatory statements are written and adopted. 2347

Background: For the past twenty years, the United States military has enhanced situational awareness during night missions by employing night vision devices

(NVD) of various types. These devices enable the user to identify objects in the NVD field of view that are otherwise unrecognizable in the low illumination of the night environment. NVD's have been championed as the tools that virtually turn night into day. Some common employment of NVD's are NVGs by infantry, aviation and naval forces, starlight scopes by infantry, forward looking infrared by aviation and thermal sights by armor units. A specific NVG, Gen III image intensifier tube, amplifies small amounts of light between the spectral range of 600nm to 930nm. The NVG's signal to noise ratio is excellent during high illumination but falls off dramatically during low light conditions. Unfortunately, the majority of military night missions occur below starlight illumination conditions. Consequently, NVG users report decreased visual acuity, poor contrast, increased scintillations, and the loss of depth perception due to degraded texture gradients. As a result, NVG users have a higher probability of making sensory-perceptual errors which are the most common causal factor related to mishaps involving NVG use. In fact, from 1973-1993 US Navy and Marine Corps forces have had 13 rotary wing and 5 fixed wing class A mishaps employing NVGs, resulting in 15 helos, 6 jets, and 39 lives lost. For most NVGs the best visual acuity under ideal conditions is 20/40 resolution. Military pilots corrected or uncorrected visual acuity is 20/20, while Federal Aviation Regulations (FARs) state that civilian nighttime visual acuity must be 20/40. In the military, night vision goggle usage is strictly controlled. The military aviator must maintain physical, training, and performance requirements to use NVGs; however these strict guidelines will be difficult to enforce for civilian NVG users. RTCA 196 Minimum Operational Performance Standards document outlines numerous issues that the Federal Aviation Administration must consider if civilian pilots are authorized to use NVGs. A high priority issue identified by the RTCA 196 committee was NVG resolution – what are the effects of degraded visual acuity on NVG detectability (“Minimum visual acuity (VA) requirements” and “Pilot vision requirements for NVG operations” from Simpson, Turpin, and Gardner, 2001, report entitled “Human Factors Issues for Civil Aviation use of Night Vision Goggles”)?

Output: Final report. 1) Incorporate NVG tube MTF values into the MATLAB Image Discrimination model 2) Modify MATLAB graphical user interface to include NVG MTFs and other relevant NVG parameters that may be modeled. 3) Perform NVG detectability analyses for different observers' visual acuities, e.g, 20/10, 20/20, 20/40, 20/60, 20/80, ..., 20/200, across the three different NVG tubes (40, 50, and 64 lp/mm).

Regulatory Link: RTCA-196

Requirement ID: 865Sponsor Organization: AFSPOC: Hooper HarrisRequirement Title: Simultaneous Non-interfering Operations - Quantify VFR Navigation PerformanceFunded Requirement:

- FY02: Yes
- FY03: Yes
- FY04: Yes
- FY05: Yes

Requirement Statement: To determine NAV performance of VFR helo pilots using IFR qualified GPS receivers. AFS needs to quantify helo pilot NAV performance for IFR and VFR pilotage which will allow the development of procedures to integrate within the national airspace system.255

Background: A major part of the future changes in the NAS to improve operations for helicopters will be the emergence of simultaneous Non-Interfering Operations (SNI) for VFR helicopters and fixed wing traffic (IFR and VFR). To achieve this Airspace Redesign, to what extent is the minimum amount of airspace needed to protect the VFR helicopter flying a SNI leg/route from a human performance standpoint. The proposed concept to be employed is based on satellite navigation technology. In turn, the amount of airspace that would be needed to protect the minimally equipped helicopter will be based on technology. Human Factors questions include: To evaluate the relationship between pilotage and radio navigation. a) what are the ATC procedures that a helo VFR pilot should follow to optimize national airspace capacity? b) what is the amount of time the pilot fixates on landmarks versus GPS output. c) does the pilot fly the GPS needle? During VFR the pilot should use landmark references but the pilot may shift visual attention to the GPS which may adversely affect pilotage. c) does the GPS affect pilot scan?

Output: A report that recommends the minimum Required Navigation Performance (RNP) value for a VFR helicopter equipped with an IFR GPS. The minimum RNP value will help ATC develop procedures for VFR SNI routes

Regulatory Link: This research request is directly linked to HR 1000 Section 103 of the Agency's performance plan. (Implementation of the infrastructure for helicopters and tiltrotors) and Administrator's 2001 Vertical Flight Policy Statement

Requirement ID: 646

Sponsor Organization: ASW

POC:

Requirement Title: Tiltrotor controls

Funded Requirement:

- FY02: No
- FY03: No
- FY04:
- FY05:

Requirement Statement:

Background: A new SFAR certification initiative will take place for the new aerodynamic design called the "tiltrotor aircraft". Much research has been dedicated to the tiltrotor design, but none concerning the human factors aspects of flight controls for civil and pilot certification. One particular control of interest is the nacelle tilt control. This control is new to all aerodynamic designs, and is the pilot control that changes the angle of the nacelle blades (propellers on the wings) to give the design aerodynamic thrust. It also enables the pilot to convert from "helicopter mode", or t/o and landing mode, to "airplane mode". The aircraft companies have made many designs to look at proper pilot to aircraft interface...but do to many unknowns and funding the initiatives have been slowed way down. This activity is a new technology which also falls under the Agency's performance plan.

Output:

Regulatory Link:

Requirement ID: 643Sponsor Organization: AFSPOC: Hooper HarrisRequirement Title: Vertical Flight IFR approach lighting requirementsFunded Requirement:

- FY02: No
- FY03: No
- FY04:
- FY05:

Requirement Statement: Request a thorough literature review be done to sum up the recommended approach lighting standard. In turn, sum up the current issues that have not accounted for human factors concerns. Some examples of issues would include the following: what is needed for an approach lighting system for helicopters? What type of cueing should it support, roll, alignment, and rate of closure? What is the impact of approach angle on cueing? (i.e. 9 degrees or 12 degrees for a tiltrotor) What is the impact of the look down angle in the flight deck for cueing? By defining all respective cues that could be addressed, then request a look at potential solutions for desired cueing.⁶⁷⁵

Background: When WAAS and LAAS are realities in 2001 and 2002, the potential of precision approaches to heliports/vertiports will be high. Currently, the only approach lighting system that is approved for helicopters are HALS, that lack the appropriate cueing and look down angle for precision approach helicopter operations to a point. There have been several studies to date concerning the need for an approach lighting standard, however none have been done from a Human Factors standpoint (i.e. taken into account pilot workload and helicopter design). Request a thorough literature review be done to sum up the recommended approach lighting standard. In turn, sum up the current issues that have not accounted for human factors concerns. Some examples of issues would include the following: what is needed for an approach lighting system for helicopters? What type of cueing should it support, roll, alignment, and rate of closure? What is the impact of approach angle on cueing? (i.e. 9 degrees or 12 degrees for a tiltrotor) What is the impact of the look down angle in the flight deck for cueing? By defining all respective cues that could be addressed, then request a look at potential solutions for desired cueing. In turn, although this appears as an airport requirement, without this data it is undetermined if vertical flight aircraft needs to be limited by approach angle for IFR precision helicopter approaches based on human performance for lighting cueing.

Output:Regulatory Link:

Requirement ID: 629Sponsor Organization: ASWPOC: Lorry FaberRequirement Title: Vertical Flight NVG MaintenanceFunded Requirement:

- FY02: No
- FY03: No
- FY04:
- FY05:

Requirement Statement: Research to establish AC for standard Human Factors inspection guidelines for an NVG component repair station. RTCA SC-196 recommends in their operational concept and Minimum Operational Performance Standards that NVG's shall be maintained through an FAA Repair Station. This station will perform daily maintenance according to the manufacturer's (FAA-approved) continued airworthiness instructions per technical standard order or supplemental type certificate.⁴⁶²

Background: Research to establish AC for standard Human Factors inspection guidelines for an NVG component repair station. RTCA SC-196 recommends in their operational concept and Minimum Operational Performance Standards that NVG's shall be maintained through an FAA Repair Station. This station will perform daily maintenance according to the manufacturer's (FAA-approved) continued airworthiness instructions per technical standard order or supplemental type certificate

Output:Regulatory Link:

Requirement ID: 642Sponsor Organization: AFSPOC:Requirement Title: What is a too compelling and distracting flight display for Vertical Flight?Funded Requirement:

- FY02: No
- FY03: No
- FY04:
- FY05:

Requirement Statement:

Background: The hypothesis is that performance will improve to a point with improved displays to a point of diminishing returns, or task saturation. The purpose of the new project would be to define what that breakpoint is in displays. At what point do we have a "compelling" display that distracts the pilot resulting in reduced performance. This recommendation is also to head off a possible NTSB request based on accident results like the BK-117 in Florida in May. With the addition of FIS-B and ADS-B information to the cockpit like the Capstone project at what point do we say enough. Also, with the uniqueness of Vertical flight operations and the demographics of the pilot community's age and experience getting younger. These displays may have different effects on a minimally trained VFR helicopter pilot.

Output:Regulatory Link:

Appendix III

Human Factors Vertical Flight Fiscal Year Project Planning

FY03 Proposed Projects

FY04 Proposed Projects

FY05 Proposed Projects

**Human Factors Vertical Flight
FY03 Proposed Projects (contract dollars)**

Project Title	Performer	Sponsor	Req ID
Discrimination Model To Predict Night Vision Goggle Target Detection	NASA Ames (Albert Ahumada)	ASW-100 (Lorry Faber)	<u>798</u>
Determine NAV performance of VFR helicopter pilots using IFR qualified GPS receivers, RNP Measurement	Naval Postgraduate School (Rudy Darken), NASA Ames (Jeff Mulligan)	AFS-400 (Hooper Harris)	<u>865</u>
Rotocraft Precision Visual Flight Rules Simultaneous Non-Interfering Human Factors Project	Satellite Technology Implementation	AFS-400 (Hooper Harris)	<u>865</u>

**Human Factors Vertical Flight
FY04 Proposed Projects (contract dollars)**

Project Title	Performer	Sponsor	Req ID
Determine NAV performance of VFR helicopter pilots using IFR qualified GPS receivers, RNP Measurement	Naval Postgraduate School (Rudy Darken), NASA Ames (Jeff Mulligan)	AFS-400 (Hooper Harris)	<u>865</u>
Rotocraft Precision Visual Flight Rules Simultaneous Non-Interfering Human Factors Project	Satellite Technology Implementation	AFS-400 (Hooper Harris)	<u>865</u>

**Human Factors Vertical Flight
FY05 Proposed Projects (contract dollars)**

Project Title	Performer	Sponsor	Req ID
Determine NAV performance of VFR helicopter pilots using IFR qualified GPS receivers, RNP Measurement	Naval Postgraduate School (Rudy Darken), NASA Ames (Jeff Mulligan)	AFS-400 (Hooper Harris)	<u>865</u>
Rotocraft Precision Visual Flight Rules Simultaneous Non-Interfering Human Factors Project	Satellite Technology Implementation	AFS-400 (Hooper Harris)	<u>865</u>